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FORM PTO-1390 (REV 5-93)		U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER 420/50771	
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371					
INTERNATIONAL APPLICATION NO. PCT/DE00/02115		INTERNATIONAL FILING DATE June 28, 2000		PRIORITY DATE CLAIMED July 2, 1999	
TITLE OF INVENTION IMAGE REPRESENTATION SYSTEM AND METHOD FOR VEHICLES					
APPLICANT(S) FOR DO/EO/US DAIMLERCHRYSLER AG					
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:					
1.	<input checked="" type="checkbox"/>	This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.			
2.	<input type="checkbox"/>	This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371			
3.	<input type="checkbox"/>	This express request to begin national examination procedures (35 U.S.C. 371(f) at any time rather than delay Examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).			
4.	<input checked="" type="checkbox"/>	A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.			
5.	<input checked="" type="checkbox"/>	A copy of the International Application as filed (35 U.S.C. 371(c)(2)).			
		a.	<input type="checkbox"/>	is transmitted herewith (required only if not transmitted by the International Bureau).	
		b.	<input checked="" type="checkbox"/>	has been transmitted by the International Bureau	
		c.	<input type="checkbox"/>	is not required, as the application was filed in the United States Receiving Office (RO/US)	
6.	<input checked="" type="checkbox"/>	A translation of the International Application into English (35 U.S.C. 371(c)(2)).			
		Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))			
		a.	<input type="checkbox"/>	are transmitted herewith (required only if not transmitted by the International Bureau).	
		b.	<input type="checkbox"/>	have been transmitted by the International Bureau.	
		c.	<input type="checkbox"/>	have not been made; however, the time limit for making such amendments has NOT expired.	
		d.	<input type="checkbox"/>	have not been made and will not be made.	
		A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).			
9.	<input checked="" type="checkbox"/>	An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)) (Unexecuted, 2 pages)			
10.	<input type="checkbox"/>	A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).			
Item 11. to 16. below concern other document(s) or information included:					
11.	<input checked="" type="checkbox"/>	An Information Disclosure Statement under 37 CFR 1.97 and 1.98.			
12.	<input type="checkbox"/>	An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.			
13.	<input checked="" type="checkbox"/>	A FIRST preliminary amendment. A SECOND or SUBSEQUENT preliminary amendment.			
14.	<input checked="" type="checkbox"/>	A substitute specification and marked-up copy thereof.			
15.	<input type="checkbox"/>	A change of power of attorney and/or address letter.			
16.	<input checked="" type="checkbox"/>	Other items or information:			
		a.	PCT/IB/308		
		b.	PCT/RO/101		
		c.	PCT/IB/301		
		d.	PCT/IB/304		
		e.	Two (2) Sheets Drawings (Figs. 1-2)		

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)		INTERNATIONAL APPLICATION NO		ATTORNEY'S DOCKET NUMBER	
10:013/24		PCT/DE00/02115		420/50771	
17. <input checked="" type="checkbox"/> The following fees are submitted:				CALCULATIONS	PTO USE ONLY
Basic National Fee (37 CFR 1.492(a)(1)-(5)):					
Search Report has been prepared by the EPO or JPO \$ 890.00				890.00	
International preliminary examination fee paid to USPTO (37 CFR 1.482) \$ 690.00					
No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) \$ 740.00					
Neither international preliminary examination fee (37 CFR 1.482) nor International search fee (37 CFR 1.445(a)(2)) paid to USPTO \$ 1000.00					
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) \$ 100.00					
ENTER APPROPRIATE BASIC FEE AMOUNT =				\$890.00	
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input checked="" type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				\$130.00	
Claims	Number Filed	Number Extra	Rate		
Total Claims	22- 20 =	2	X \$18.00	\$36.00	
Independent Claims	- 3 =	3	X \$84.00	\$	
Multiple dependent claims(s) (if applicable)			+ \$280.00	\$	
TOTAL OF ABOVE CALCULATIONS=				\$1056.00	
Applicant claims Small Entity Status (See 37 CFR §1.27) <input type="checkbox"/> yes <input type="checkbox"/> no.					
Reduction by 1/2 for filing by small entity, if applicable.				\$	
SUBTOTAL =				\$1056.00	
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				\$	
TOTAL NATIONAL FEE =				\$1056.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28,3.31). \$40.00 per property +				\$	
TOTAL FEE ENCLOSED =				\$1056.00	
				Amount to be:	
				refunded \$	
				Charged \$	
a. <input checked="" type="checkbox"/> One check in the amount of \$1056.00 for the filing fee of \$890.00, the excess claim charges of \$36.00, and the surcharge of \$130.00 for late filing of the Declaration fee are enclosed					
b. <input type="checkbox"/> Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.					
c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees, which may be required, or credit any overpayment to Deposit Account No. 05-1323. A duplicate copy of this sheet is enclosed.					
NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.					
SEND ALL CORRESPONDENCE TO:					
Crowell & Moring, L.L.P.				SIGNATURE	
P.O. Box 14300				Vincent J. Sunderdick	
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Fax No. (202) 628-8844				REGISTRATION NUMBER	
				January 2, 2002	
				DATE	

Attorney Docket: 420/50771
PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: THORSTEINN HALLDORSSON
Serial No.: To Be Assigned
Filed: January 2, 2002 Intl. Application No.: PCT/DE00/02115
Title: IMAGE REPRESENTATION SYSTEM AND METHOD FOR
VEHICLES

PRELIMINARY AMENDMENT

Box PCT
Commissioner for Patents
Washington, D.C. 20231

Sir:

Please enter the following amendments to the specification, claims and abstract prior to the examination of the application.

IN THE CLAIMS:

Please amend claims 1-17 as follows:

1. (AMENDED) An imaging system for motor vehicles, comprising
a projector,
a holographic ray uniter, which guides narrow band light to a viewer to
produce a virtual image at the viewing location,
a holographic screen, which is produced by means of holographic shooting
of a real screen and which scatters incident narrow band light of one or more
wavelengths at a predetermined solid angle,

wherein the projector projects the light onto the holographic screen to produce real images on said holographic screen, wherein the holographic ray uniter is transparent to broad band ambient light, and wherein the narrow band light, scattered by the holographic screen, is guided to the viewer.

2. (AMENDED) The imaging system, as claimed in claim 1, wherein a camera system, which is coupled to the projector, shoots images outside the motor vehicle to enable the view to at least one of the rear and the side.

3. (AMENDED) The imaging system, as claimed in claim 1, wherein the holographic ray uniter is arranged, from the viewer's view, at least one of, in front of and on, the windshield of the motor vehicle.

4. (AMENDED) The imaging system, as claimed in claim 1, wherein the ray uniter is a holographic mirror.

5. (AMENDED) The imaging system, as claimed in claim 1, wherein the ray uniter is a ray deflector with lens function.

6. (AMENDED) The imaging system, as claimed in claim 1, wherein the projector comprises lasers with the primary colors red, green and blue.

7. (AMENDED) The imaging system, as claimed in claim 1, wherein the projector comprises an image modulator.

8. (AMENDED) The imaging system, as claimed in claim 1, wherein the ray uniter is disposed on a transparent plate.

9. (AMENDED) The imaging system, as claimed in claim 1, wherein the holographic ray uniter and the holographic screen are arranged in such a manner that the virtual image appears for the viewer enlarged behind the windshield of the motor vehicle at a distance of at least 1.5 meters to the viewer.

10. (AMENDED) The imaging system, as claimed in claim 1, further comprising a device for coupling the imaging to the motor vehicle control functions.

11. (AMENDED) The imaging system, as claimed in claim 1, wherein at least one of the ray uniter and the holographic screen is designed and arranged in such a manner that the light cone coming from the ray uniter is limited to the possible dwelling space of the viewer's eyes.

12. (AMENDED) The imaging system, as claimed in claim 1, wherein at least one of the ray uniter and the holographic screen is designed and arranged in such a manner that they exhibit an imaging function.

13. (AMENDED) A method for displaying images in motor vehicles comprising the steps of:

projecting images on a holographic screen;

guiding the light rays, coming from the holographic screen, into a viewer's eyes, producing virtual images in a surface cutout of the windshield of the motor vehicle by means of a hologram connected in series to the holographic screen to provide ray deflection.

14. (AMENDED) A method for displaying images in motor vehicles comprising the steps of:

projecting narrow band light of one or more wavelengths on a holographic screen, which is produced by holographic shooting of a real screen, to produce a real image on the holographic screen, and

guiding the light rays, scattered by the holographic screen at a predetermined solid angle, into a viewer's eye,

whereby the light rays are deflected through a hologram and produce a virtual image at the viewer, while simultaneously broad band light of the environment lying behind the hologram passes through the hologram.

15. (AMENDED) The method as claimed in claim 13, wherein images of the view from at least one of the rear and the perspective of the motor vehicle side mirrors are faded into the peripheral area of the windshield.

16. (AMENDED) The method as claimed in claim 13, wherein the angular distance between the visual axis in the direction of travel and the virtual image is less than 30 degrees.

17. (AMENDED) The method as claimed in claim 13, wherein at least one of the rear and side images from the motor vehicle are displayed as a function of the driving state or the motor vehicle control functions.

(A copy of the marked-up version of amended claims 1-17 is attached to this Preliminary Amendment).

Please ADD new claims 18-22 as follows:

18. (NEW) The imaging system as claimed in claim 7, wherein the image modulator is at least one of ferroelectric modulators and micro-mirror devices.

19. (NEW) The imaging system according to claim 9, wherein the distance is at least 3 meters.

20. (NEW) The method according to claim 16, wherein the angular distance is substantially 10 degrees.

21. (NEW) The method as claimed in claim 14, wherein images of the view from at least one of the rear and the perspective of the motor vehicle side mirrors are faded into the peripheral area of the windshield.

22. (NEW) The method as claimed in claim 14, wherein the angular distance between the visual axis in the direction of travel and the virtual image is less than 30 degrees.

IN THE ABSTRACT:

Please substitute the new Abstract of the Disclosure submitted herewith on a separate page for the original Abstract presently in the application.

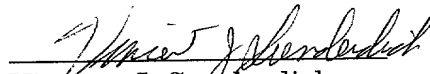
REMARKS

Entry of the amendments to the specification, claims and abstract before examination of the application is respectfully requested.

If there are any questions regarding this Preliminary Amendment or this application in general, a telephone call to the undersigned would be appreciated since this should expedite the prosecution of the application for all concerned.

Respectfully submitted,

Date: January 2, 2002


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--ABSTRACT OF THE DISCLOSURE

An imaging system for motor vehicles has a holographic screen, which scatters incident narrow band light at a predetermined solid angle, and a modulator and a lens to project images on the holographic screen. A holographic, transparent ray uniter, which allows broad band ambient light to pass through essentially unimpeded, guides the narrow band light, coming from the holographic screen, to the viewer, whereby a virtual image is produced at the viewing location by means of an imaging function. Images from the outside of the motor vehicle are shot by means of a camera system and are faded as virtual images into the windshield of the motor vehicle in order to enable there additionally a view to the rear or to the side.--

VERSION WITH MARKINGS TO SHOW CHANGES MADE

Please amend claims 1-17 as follows:

1. (AMENDED) [Imaging] An imaging system for motor vehicles, comprising

a projector [(14, 15)], [and]

a holographic ray uniter [(11, 11', 11'')], which guides narrow band light to a viewer [(17)] to produce a virtual image [(16, 16', 16'')] at the viewing location,

[characterized by]

a holographic screen [(13)], which is produced by means of holographic shooting of a real screen and which scatters incident narrow band light of one or more wavelengths at a predetermined solid angle,

[whereby] wherein the projector [(14, 15)] projects the light onto the holographic screen [(13)] to produce [there] real images on said holographic screen, [and] wherein the holographic ray uniter [(11, 11', 11'')] is transparent to broad band ambient light[;], and wherein the narrow band light, scattered by the holographic screen [(13)], is guided to the viewer [(17)].

2. (AMENDED) [Imaging] The imaging system, as claimed in claim 1, [characterized by] wherein a camera system, which is coupled to the projector, [to shoot] shoots images outside the motor vehicle to enable the view to at least one of the rear and [/ or to] the side.

3. (AMENDED) [Imaging] The imaging system, as claimed in claim 1 [or 2], [characterized in that] wherein the holographic ray uniter [(11, 11', 11'')] is arranged, from the viewer's view, at least one of, in front of and [/ or] on, the windshield [(12)] of the motor vehicle.

4. (AMENDED) [Imaging] The imaging system, as claimed in [one or more of the preceding claims] claim 1, [characterized in that] wherein the ray uniter [(11, 11', 11'')] is [designed as] a holographic mirror.

5. (AMENDED) [Imaging] The imaging system, as claimed in [one or more of the preceding claims] claim 1, [characterized in that] wherein the ray uniter [(11, 11', 11'')] is [designed as] a ray deflector with lens function.

6. (AMENDED) [Imaging] The imaging system, as claimed in [one or more of the preceding claims] claim 1, [characterized in that] wherein the projector [(14, 15)] comprises lasers with the primary colors red, green and blue.

7. (AMENDED) [Imaging] The imaging system, as claimed in [one or more of the preceding claims] claim 1, [characterized in that] wherein the projector [(14, 15)] comprises an image modulator [(14), in particular ferroelectric liquid modulators and / or micro mirror devices].

8. (AMENDED) [Imaging] The imaging system, as claimed in [one or more of the preceding claims] claim 1, [characterized in that] wherein the ray uniter [(11, 11', 11'')] is disposed on a transparent plate.

9. (AMENDED) [Imaging] The imaging system, as claimed in [one or more of the preceding claims] claim 1, [characterized in that] wherein the holographic ray uniter [(11, 11', 11'')] and the holographic screen [(13)] are arranged in such a manner that the virtual image appears for the viewer [(17)] enlarged behind the windshield [(12)] of the motor vehicle[, preferably] at a distance of at least 1.5 meters to the viewer[, especially preferred at a distance of at least 3 meters].

10. (AMENDED) [Imaging] The imaging system, as claimed in [one or more of the preceding claims] claim 1, [characterized by] further comprising a device for coupling the imaging to [vehicle control functions and / or] the motor vehicle control functions.

11. (AMENDED) [Imaging] The imaging system, as claimed in [one or more of the preceding claims] claim 1, [characterized in that] wherein at least one of the ray uniter [(11, 11', 11'')] and [/ or] the holographic screen [(13)] is [/ are] designed and arranged in such a manner that the light cone coming from the

ray uniter [(11, 11', 11'')] is limited to the possible dwelling space of the viewer's [(17)] eyes.

12. (AMENDED) [Imaging] The imaging system, as claimed in [one or more of the preceding claims] claim 1, [characterized in that] wherein at least one of the ray uniter [(11, 11', 11'')] and [/ or] the holographic screen [(13)] is [/ are] designed and arranged in such a manner that they exhibit an imaging function.

13. (AMENDED) [Method] A method for displaying images in motor vehicles [with] comprising the steps of:

[Project] projecting images on a holographic screen [(13)]; [and guide]

guiding the light rays, coming from the holographic screen [(13)], into a viewer's [(17)] eyes, [whereby] producing virtual images [(16, 16', 16'')] are produced] in a surface cutout of the windshield [(12)] of the motor vehicle by means of a hologram[, whose purpose is ray deflection [(11, 11', 11'')] and which is] connected in series to the holographic screen [(13)] to provide ray deflection.

14. (AMENDED) [Method] A method for displaying images in motor vehicles [with] comprising the steps of:

[Project] projecting narrow band light of one or more wavelengths on a holographic screen [(13)], which is produced by holographic shooting of a real screen, to produce a real image on the holographic screen [(13)], and

[guide] guiding the light rays, scattered by the holographic screen [(13)] at a predetermined solid angle, into a viewer's [(17)] eye,

whereby the light rays are deflected through a hologram and produce a virtual image at the viewer [(17)], while simultaneously broad band light of the environment lying behind the hologram passes through the hologram.

15. (AMENDED) [Method,] The method as claimed in claim 13 [or 14], wherein images [(16, 16', 16'')] of the view [to] from at least one of the rear and [/ or from] the perspective of the motor vehicle side mirrors are faded into the peripheral area of the windshield [(12)].

16. (AMENDED) [Method,] The method as claimed in [one or more of the claims] claim 13 [to 15], wherein the angular distance between the visual axis in the direction of travel and the virtual image [(16, 16', 16'')] is less than 30 degrees[, preferably approximately 10 degrees].

17. (AMENDED) [Method,] The method as claimed in [one or more of the claims] claim 13 [to 16], wherein at least one of the rear and [/ or] side

images from the motor vehicle are displayed as a function of the driving state or the motor vehicle control functions.

2/pv

Docket No.: 420/50771
Specification – Clean Copy

TITLE OF THE INVENTION

IMAGE REPRESENTATION SYSTEM AND METHOD FOR VEHICLES

BACKGROUND AND SUMMARY OF THE INVENTION

[0001] This application claims the priority of German Patent Document 199 30 910.5, filed July 2, 1999, the disclosure of which is expressly incorporated by reference herein.

[0002] The present invention relates to an imaging system for motor vehicles and a method for displaying images in motor vehicles.

[0003] It is well-known that the view in the rearward direction to observe the following traffic from a motor vehicle is rendered possible by means of interior and outside mirrors. This applies both to cars, as well as to trucks and busses. The use and simplicity of such rearview and side view mirrors is undisputed. However, they have several limitations and drawbacks, for example, with respect to safety and economical driving.

[0004] One drawback of the interior or rearview mirror is the limitation of the view in the direction of the rear due to the rear window or passengers, located in the motor vehicle. Furthermore, the view by means of the left outside mirror is not complete, but rather has a so-called "dead angle", which is frequently the cause of traffic accidents when changing lanes.

[0005] Another grave drawback of the rearview and side view mirrors is that for viewing purposes it is necessary to rotate the view to the side by an angle of approximately 30 degrees to 45 degrees. When the driver looks into the mirror, his attention to the view ahead is extremely limited. The reason lies in the fact that the distinct vision decreases very rapidly with the angular distance from the visual axis; and at a viewing angle exceeding 30 degrees only a weak recognition of outlines and shapes without clear distance perception is possible. This is not at all adequate to react quickly to unexpected traffic obstructions or situations on the street.

[0006] In addition, when driving in the dark, the reflection from headlights of other motor vehicles is intense in the outside mirrors and the interior rearview mirror. Owing to the blinding effect, this feature is very disturbing and fatigues the driver on long trips. Frequently it is also the cause of accidents.

[0007] Since the outside mirrors project beyond the side limits of the motor vehicle body, they can constitute an obstruction or danger for other traffic participants and also be damaged, for example, when driving through very narrow streets or very close to other traffic participants. In addition, the outside mirrors can become rapidly dirty due to their unprotected attachment to the car, thus impairing the view.

[0008] Another major drawback of the outside mirrors is their effect on the C value, the result of which is an economic drawback. When driving fast on

country roads and freeways, the air resistance of the side mirrors increases the fuel consumption of cars by approximately 5% to 10%. Another disturbing factor is the wind noise, generated during the trip by turbulence at the side mirrors.

[0009] A known approach to solving the aforementioned problems lies in the use of cameras, which can be embedded, for example, in the vehicle body. The viewing angle around the vehicle can be significantly increased, for example, with several cameras behind and on the side of the body. Then the image shot with the cameras is displayed on a monitor in the interior of the motor vehicle.

[0010] However, the above solution has the drawback that the displayed image is very close to the viewer. In contrast to looking into the conventional rearview or side mirror, looking at the monitor requires that the eyes continuously readapt, a feature that fatigues the driver of the motor vehicle. When the driver's line of vision is directed alternately forward through the windshield or backward through the rearview mirror, the eyes must accommodate and converge. In addition, the image on the monitor does not appear vertical in relation to the visual axis, since for space reasons it can hardly be attached in such a manner in the motor vehicle.

[0011] Another significant drawback of such systems is the intrinsic brightness of the monitor over a wide solid angle. Thus, the interior of the motor vehicle is significantly brightened in the dark; and the driver's view in the direction of the outside is rendered significantly difficult.

[0012] Therefore, the object of the present invention is to provide an imaging system for motor vehicles, which enables a display with high image quality and offers a higher degree of ergonomics and safety in traffic. Furthermore, a method for displaying images in motor vehicles shall be disclosed. Such a method enables the motor vehicle driver to view images with high quality during the trip without diverting his attention or tiring him due to continuous readaptation of the eyes.

[0013] The inventive imaging system for motor vehicles comprises a holographic screen, which scatters incident narrow band light of one or more wavelengths at a predetermined solid angle, a projector to project images on the holographic screen, and a holographic, transparent ray uniter, which allows broad band ambient light to pass in essence unimpeded and which guides the narrow band light, coming from the holographic screen, to the viewer to produce a virtual image at the viewing location.

[0014] The invention combines the advantages of conventional rearview mirrors, such as high image quality and no necessity of readaptation at rapidly changing distances, with the advantages of camera systems. On the one hand, a high degree of ergonomics and image quality are achieved; and, on the other hand, safety and economic efficiency while driving are increased.

[0015] A camera system can be coupled to the imaging system of the invention. Said camera is focused on the rear and / or the side and thus delivers

images from the outside of the motor vehicle to enable a view to the rear and / or to the side. From the driver's viewpoint the ray uniter is mounted advantageously in front of and / or directly on the windshield of the motor vehicle. Preferably the ray uniter is designed as a holographic mirror or as a ray deflector with lens function. The projector can comprise lasers with the primary colors red, green and blue.

[0016] Preferably the projector has an image modulator, for example in the form of ferroelectric liquid modulators or micro mirror devices.

[0017] The ray uniter can be mounted on a transparent plate, which is made, for example, of glass or plastic. In particular, the holographic ray uniter is arranged in such a manner together with the holographic screen that the virtual image appears for the viewer enlarged behind the windshield, preferably at a distance of at least 1.5 meters, especially preferred at a distance of at least 3 meters.

[0018] Furthermore, there can be a device for coupling the imaging to vehicle control functions or preset driving situations. The ray uniter and / or the holographic screen is / are designed and / or arranged preferably in such a manner that the light cone coming from the ray uniter is limited to the possible dwelling space of the viewer's eyes. Preferably the holographic screen and the ray uniter are designed and / or arranged in such a manner that they exhibit an imaging function.

[0019] The inventive method for displaying images in motor vehicles includes projecting images on a holographic screen and guiding the light rays, coming from the holographic screen, into a viewer's eyes, whereby virtual images are produced in a surface cutout of the front window and / or windshield by means of a hologram, whose purpose is ray deflection and which is connected in series to the holographic screen. Thus, the ergonomics of driving motor vehicles is increased; and images of the outside can be offered with high quality to the motor vehicle driver, whereby the aforementioned drawbacks of rearview or side mirrors and monitors are overcome.

[0020] With this method the images can be taken with a camera system in order to enable, in the windshield, the view in the rearward direction and / or to the side. Preferably images of the view toward the rear and / or from the perspective of the vehicle side mirrors are faded into the peripheral area of the windshield. Preferably the angular distance between the visual axis of the vehicle driver in the direction of travel and the virtual image is less than 30 degrees, especially preferred approximately 10 degrees. Furthermore, the rear and side images from the motor vehicle can be displayed as a function of the driving states or the vehicle control functions.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The invention is described as an illustrative example with reference to the figures, where

[0022] Figure 1 is a longitudinal view of the motor vehicle with the inventive imaging system and the beam trajectory; and

[0023] Figure 2 is a sectional view from the top with different ray paths in a car, according to a specific embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0024] Figure 1 is a side view or a sectional view of the central plane of the driver of a motor vehicle to depict as a schematic the imaging system and the beam trajectory, according to a preferred embodiment of the invention. In the motor vehicle there is a holographic screen 13, which is produced by means of a holographic shot of a real screen. By means of an image modulator 14 and a lens 15 light is projected on the holographic screen 13 to display images. In this manner images, produced by a light source and the image modulator 14, are imaged as real through the lens 15 on the holographic screen 13. A holographic, transparent ray uniter 11 or combiner is arranged in such a manner that it deflects or almost completely reflects the light rays, issuing from the holographic screen 13 as a consequence of the image projection, in the direction of the viewer 17. The holographic, transparent ray uniter 11 comprises a hologram with the

imaging properties of a concave mirror or a lens so that, when viewing the ray uniter 11, a virtual image 16 is produced at the viewing location of the driver 17.

[0025] The ray uniter 11 is arranged, as seen from the viewer 17, in front of the windshield 12 of the motor vehicle. Owing to its design as a transparent hologram, it allows the broad band light, coming from the outside through the windshield 12, to pass through virtually unimpeded so that the driver can look out through the ray uniter 11. However, the hologram of the ray uniter 11 is designed in such a manner that narrow band or monochromatic light, for example laser light in the primary colors red, green and blue, which comes from the holographic screen 13, is reflected almost completely in the direction of the driver.

[0026] In the embodiment, depicted here, the projector, comprising modulator 14 and lens 15, and the holographic screen 13 are arranged inside the dashboard of the motor vehicle. Through an opening, which is adapted to the opening angle 18 of the ray trajectory between the holographic screen 13 and the ray uniter 11, the light rays pass through the ray uniter 11 to the viewer 17.

[0027] In the embodiment, depicted here, the ray uniter 11 is designed as a holographic mirror. It can be mounted either directly on the windshield 12 or on a separate transparent plate, which is disposed in front of the windshield 12. As an alternative, it is also possible that the ray uniter 11 is designed in

transmission, whereby it exhibits a lens function, which causes a suitable deflection of the light rays.

[0028] Photopolymer, photoresist, silver halide and dichromated gelatin holograms can be used, for example, as holographic materials or holograms for the holographic screen 13 and the ray unit 12. The holographic screen 13 and the ray unit 12 can be designed to work in reflection or also in transmission.

[0029] The holographic screen 13 and its production are detailed in the German Patent DE 197 00 162 A1 document, to which explicit reference is made. In production, a real, for example white, screen is imprinted into a hologram with the projected laser wavelengths that are used later. During the shooting process, the screen is illuminated in such a manner with the lens ray that its backscatter characteristic is the same as desired later in application. An expanded pencil of rays, which issues from a corresponding location, like the subsequent projecting ray, serves as the reference ray during holographic shooting of the screen. For example, a scanning projecting ray can be used for reproduction. By means of image modulators 14 and use of projected wavelengths in the primary colors red, green and blue, a real image can be produced on the hologram or the holographic screen. Other possibilities and details of the production are disclosed in the aforementioned document.

[0030] Primarily red, green and blue crystal lasers, glass fiber lasers and diode lasers are used as the source of illumination for the full color imaging at

the image modulators 14. The power range of the lasers used is in an order of magnitude of a few milliwatts.

[0031] Suitable full color image modulators are, for example, ferroelectric liquid modulators or micro mirror devices or micro mirror modulators. In this respect different imaging standards, such as VGR, XGR, SXGR, PAL, etc., can be used.

[0032] The ray uniter 11 and the holographic screen 13 are synchronized in such a manner that the virtual image 16 appears at a certain distance in front of the windshield 12. Thus, there is no need for the alternating accommodation of the eyes for near and far vision that is otherwise necessary with monitors. In the embodiment, depicted here, the ray uniter 11 is disposed in front of the windshield 12 at its lower edge so that the virtual image 16 for the viewer or the car driver 17 lies in the lane 16 or in the visible front parts of the motor vehicle body, such as the hood of the engine. Therefore, the view ahead in the direction of travel is not impaired; and the angular distance between the viewing axis ahead in the direction of travel and the projected image is extremely small. In normal motor vehicles of the conventional type, this view can be set, for example, to 10 degrees. Even an angular distance of up to 30 degrees means a significant improvement compared to the view in the conventional motor vehicle mirrors or monitors.

[0033] Figure 2 depicts another embodiment of the invention, wherein several images, which are shot by separate camera systems, appear as virtual images 16, 16', 16" in the windshield or front window 12 of the motor vehicle. In this case three projectors with related holographic screens are disposed in the dashboard or behind the dashboard cover. At the windshield 12 there are the ray uniters 11, 11', 11", which lie side by side and are intended to produce the virtual images 16, 16', 16", which are, as seen from the viewer 17, behind the respective ray uniter. The cameras, projectors, holographic screens and ray uniters are arranged in such a manner that the driver 17 of the motor vehicle sees, when looking straight ahead to the front, the ray uniter 11' with the rear image 16', whereas he can see the left rear image 16 or the right rear image 16' through the respective left and right ray uniters 11, 11". Thus, for example, images, as they appear in conventionally arranged rearview and side view mirrors, can be offered in the windshield 12 as virtual images, which are at a viewing location at some distance behind the windshield 12.

[0034] Suitable cameras for shooting outside images are, for example, CCD and CMOS cameras, which cover a wide range of brightness. For example, the glare effect while driving at night can be avoided with highly dynamic CMOS cameras. It is also possible to install additionally residual light amplifying cameras and un-cooled infrared cameras to improve vision at night. In addition to the significant enlargement of the viewing angle around the car, which is the

result of arranging several cameras behind and on the side of the body, a panoramic view around the motor vehicle can be rendered possible with a suitable arrangement of a plurality of cameras.

[0035] Suitable light sources for the projection of images on the holographic screen are, besides lasers, also other monochromatic light sources, such as light emitting diodes. Color imaging is made possible through projection with the primary colors red, green and blue. The virtual images 16, 16', 16" that are produced are projected with sufficient brightness into the windshield 12, where they beam over the image of the environment lying behind it. However, with suitable adjustment of the brightness both images, that is the virtual image 16, 16', 16" and the transparent real image, can also be viewed simultaneously. Since the holographic ray unit 11 is transparent, the broad band ambient light is allowed to pass virtually unimpeded; and the view through the windshield 12 is completely unimpeded, when the additional image or the virtual image 16, 16', 16" is turned off.

[0036] Since the driver's spatial perception of the distance and the situation of other vehicles or the course of the street is based essentially on a comparison of size and the perspective perception, and less on the stereoscopic vision, a monoscopic imaging is usually adequate. Therefore, to simplify the construction, one can omit the technically difficult stereoscopic imaging in the holographic projection without any significant loss of information.

[0037] In the described arrangement the driver can see the virtual image or the auxiliary image 16, 16', 16" in the bottom area of the windshield 12. In this outer field, which otherwise remains unused for the driver, the virtual rear or side image is imaged and appears, therefore, for the viewer in the street or the engine hood of the motor vehicle.

[0038] However, it is also possible to have the image appear on a separate transparent plate, mounted in front of the windshield 12. In this case the virtual image appears through the surface of the dashboard.

[0039] In another special embodiment, the fading of the rear and / or side images into the windshield or the vehicle pane 12 is not constantly present, but rather coupled to specific driving states or controls of the motor vehicle. For example, there can be a device, which offers the driver 17 images corresponding to reversing or actuating the blink lights.

[0040] The hologram of the ray uniter 12 is designed in such a manner and focused with respect to the holographic screen 13 so that the light cone, issuing from the ray uniter 12 in the direction of the driver, is defined by the possible dwelling space of the driver's eyes. The quantity of projected light can be controlled as a function of the light ratio, for example during the day or night. Owing to the limitation of the light cone and the adjusted quantity of light there is no disturbing brightening of the vehicle interior during the night.

[0041] The inventive imaging with intercalation of a screen hologram and combining of imaging functions for virtual images with the ray uniter 11 enable optimal use of the quantity of light for the relatively wide range of motion of the motor vehicle driver 17. Narrow band sources of light, like lasers or light emitting diodes, enable full color imaging in a simple and economical construction.

[0042] In summary the invention makes it possible to fade virtual images directly into the driver's field of vision without disturbing the view ahead.

[Imaging System and Method for Motor Vehicles]

TITLE OF THE INVENTION

IMAGE REPRESENTATION SYSTEM AND METHOD FOR VEHICLES

BACKGROUND AND SUMMARY OF THE INVENTION

[0001] This application claims the priority of German Patent Document 199 30 910.5, filed July 2, 1999, the disclosure of which is expressly incorporated by reference herein.

[0002] The present invention relates to an imaging system for motor vehicles and a method for displaying images in motor vehicles.

[0003] It is well-known that the view in the rearward direction [of the rear] to observe the following traffic from a motor vehicle is rendered possible by means of interior and outside mirrors. This applies both to cars, as well as to trucks and busses. The use and simplicity of such rearview and side view mirrors is undisputed. However, they have several limitations and drawbacks, for example, with respect to safety and [economic] economical driving.

[0004] One drawback of the interior or rearview mirror is the limitation of the view in the direction of the rear due to the rear window or passengers, located in the motor vehicle. Furthermore, the view by means of the left outside mirror is not complete, but rather has a so-called "dead angle", which is frequently the cause of traffic accidents when changing lanes.

[0005] Another grave drawback of the rearview and side view mirrors is that for viewing purposes it is necessary to rotate the view to the side by an angle of approximately 30 degrees to 45 degrees. When the driver looks into the mirror, his attention to the view ahead is extremely limited. The reason lies in the fact that the distinct vision decreases very rapidly with the angular distance from the visual axis; and at a viewing angle exceeding 30 degrees only a weak recognition of outlines and shapes without clear distance perception is possible. This is not at all adequate to react quickly to unexpected traffic obstructions or situations on the street.

[0006] In addition, when driving in the dark, the reflection from headlights of other motor vehicles is intense in the outside mirrors and the interior rearview mirror. Owing to the blinding effect, this feature is very disturbing and fatigues the driver on long trips. Frequently it is also the cause of accidents.

[0007] Since the outside mirrors project beyond the side limits of the motor vehicle body, they can constitute an obstruction or danger for other traffic participants and also be damaged, for example, when driving through very narrow streets or very close to other traffic participants. In addition, the outside mirrors can become rapidly dirty due to their unprotected attachment to the car, thus impairing the view.

[0008] Another major drawback of the outside mirrors is their effect on the C value, the result of which is an economic drawback. When driving fast on

country roads and freeways, the air resistance of the side mirrors increases the fuel consumption of cars by approximately 5% to 10%. Another disturbing factor is the wind noise, generated during the trip by turbulence at the side mirrors.

[0009] A known approach to solving the aforementioned problems lies in the use of cameras, which can be embedded, for example, in the vehicle body. The viewing angle around the vehicle can be significantly increased, for example, with several cameras behind and on the side of the body. Then the image shot with the cameras is displayed on a monitor in the interior of the motor vehicle.

[0010] However, the above solution has the drawback that the displayed image is very close to the viewer. In contrast to looking into the conventional rearview or side mirror, looking at the monitor requires that the eyes continuously readapt, a feature that fatigues the driver of the motor vehicle. When the driver's line of vision is directed alternately forward through the windshield or backward through the rearview mirror, the eyes must accommodate and converge. In addition, the image on the monitor does not appear vertical in relation to the visual axis, since for space reasons it can hardly be attached in such a manner in the motor vehicle.

[0011] Another significant drawback of such systems is the intrinsic brightness of the monitor over a wide solid angle. Thus, the interior of the motor vehicle is significantly brightened in the dark; and the driver's view in the direction of the outside is rendered significantly difficult.

[0012] Therefore, the object of the present invention is to provide an imaging system for motor vehicles, which enables a display with high image quality and offers a higher degree of ergonomics and safety in traffic. Furthermore, a method for displaying images in motor vehicles shall be disclosed. Such a method enables the motor vehicle driver to view images with high quality during the trip without diverting his attention or tiring him due to continuous readaptation of the eyes.

[0013] [This problem is solved by the imaging system, according to patent claim 1, and the method for displaying images in motor vehicles, according to patent claim 13. Other advantageous features, aspects and details of the invention follow from the dependent claims, the description and the drawings.]

[0014] The inventive imaging system for motor vehicles comprises a holographic screen, which scatters incident narrow band light of one or more wavelengths at a predetermined solid angle, a projector to project images on the holographic screen, and a holographic, transparent ray uniter, which allows broad band ambient light to pass in essence unimpeded and which guides the narrow band light, coming from the holographic screen, to the viewer to produce a virtual image at the viewing location.

[0015] The invention combines the advantages of conventional rearview mirrors, such as high image quality and no necessity of readaptation at rapidly changing distances, with the advantages of camera systems. On the one hand, a

high degree of ergonomics and image quality are achieved; and, on the other hand, safety and economic efficiency while driving [is] are increased.

[0016] A camera system can be coupled to the imaging system of the invention. Said camera is focused on the rear and / or the side and thus delivers images from the outside of the motor vehicle to enable a view to the rear and / or to the side. From the [viewer's] driver's viewpoint the ray unit is mounted advantageously in front of and / or directly on the windshield of the motor vehicle. Preferably the ray unit is designed as a holographic mirror or as a ray deflector with lens function. The projector can comprise lasers with the primary colors red, green and blue.

[0017] Preferably the projector has an image modulator, for example in the form of ferroelectric liquid modulators or micro mirror devices.

[0018] The ray unit can be mounted on a transparent plate, which is made, for example, of glass or plastic. In particular, the holographic ray unit is arranged in such a manner together with the holographic screen that the virtual image appears for the viewer enlarged behind the windshield, preferably at a distance of at least 1.5 meters, especially preferred at a distance of at least 3 meters.

[0019] Furthermore, there can be a device for coupling the imaging to vehicle control functions or preset driving situations. The ray unit and / or the holographic screen is / are designed and / or arranged preferably in such a

manner that the light cone coming from the ray uniter is limited to the possible dwelling space of the viewer's eyes. Preferably the holographic screen and the ray uniter are designed and / or arranged in such a manner that they exhibit an imaging function.

[0020] The inventive method for displaying images in motor vehicles [comprises the steps:

[0021] Project] includes projecting images on a holographic screen and [guide] guiding the light rays, coming from the holographic screen, into a viewer's eyes, whereby virtual images are produced in a surface cutout of the front window and / or windshield by means of a hologram, whose purpose is ray deflection and which is connected in series to the holographic screen. Thus, the ergonomics [while] of driving motor vehicles is increased; and images of the outside can be offered with high quality to the motor vehicle driver, whereby the aforementioned drawbacks of rearview or side mirrors and monitors are overcome.

[0022] With this method the images can be taken with a camera system in order to enable, in the windshield, the view in the rearward direction [of the rear] and / or to the side. Preferably images of the view toward the rear and / or from the perspective of the vehicle side mirrors are faded into the peripheral area of the windshield. Preferably the angular distance between the visual axis of the vehicle driver in the direction of travel and the virtual image is less than

30 degrees, especially preferred approximately 10 degrees. Furthermore, the rear and side images from the motor vehicle can be displayed as a function of the driving states or the vehicle control functions.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The invention is described as an illustrative example with reference to the figures, where

[0024] Figure 1 is a longitudinal view of the motor vehicle with the inventive imaging system and the beam trajectory; and

[0025] Figure 2 is a sectional view from the top with different ray paths in a car, according to a specific embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0026] Figure 1 is a side view or a sectional view of the central plane of the driver of a motor vehicle to depict as a schematic the imaging system and the beam trajectory, according to a preferred embodiment of the invention. In the motor vehicle there is a holographic screen 13, which is produced by means of a holographic shot of a real screen. By means of an image modulator 14 and a lens 15 light is projected on the holographic screen 13 to display images. In this manner images, produced by a light source and the image modulator 14, are

imaged as real through the lens 15 on the holographic screen 13. A holographic, transparent ray uniter 11 or combiner is arranged in such a manner that it deflects or almost completely reflects the light rays, issuing from the holographic screen 13 as a consequence of the image projection, in the direction of the viewer 17. The holographic, transparent ray uniter 11 comprises a hologram with the imaging properties of a concave mirror or a lens so that, when viewing the ray uniter 11, a virtual image 16 is produced at the viewing location of the driver 17.

[0027] The ray uniter 11 is arranged, as seen from the viewer 17, in front of the windshield 12 of the motor vehicle. Owing to its design as a transparent hologram, it allows the broad band light, coming from the outside through the windshield 12, to pass through virtually unimpeded so that the driver can look out through the ray uniter 11. However, the hologram of the ray uniter 11 is designed in such a manner that narrow band or monochromatic light, for example laser light in the primary colors red, green and blue, which comes from the holographic screen 13, is reflected almost completely in the direction of the driver.

[0028] In the embodiment, depicted here, the projector, comprising modulator 14 and lens 15, and the holographic screen 13 are arranged inside the dashboard of the motor vehicle. Through an opening, which is adapted to the opening angle 18 of the ray trajectory between the holographic screen 13 and the ray uniter 11, the light rays pass through the ray uniter 11 to the viewer 17.

[0029] In the embodiment, depicted here, the ray uniter 11 is designed as a holographic mirror. It can be mounted either directly on the windshield 12 or on a separate transparent plate, which is disposed in front of the windshield 12. As an alternative, it is also possible that the ray uniter 11 is designed in transmission, whereby it exhibits a lens function, which causes a suitable deflection of the light rays.

[0030] Photopolymer, photoresist, silver halide and dichromated gelatin holograms can be used, for example, as holographic materials or holograms for the holographic screen 13 and the ray uniter 12. The holographic screen 13 and the ray uniter 12 can be designed to work in reflection or also in transmission.

[0031] The holographic screen 13 and its production are detailed in the German Patent DE 197 00 162 A1 document, to which explicit reference is made. In production, a real, for example white, screen is imprinted into a hologram with the projected laser wavelengths that are used later. During the shooting process, [it is provided that] the screen is illuminated in such a manner with the lens ray that its backscatter characteristic is the same as desired later in application. An expanded pencil of rays, which issues from a corresponding location, like the subsequent projecting ray, serves as the reference ray during holographic shooting of the screen. For example, a scanning projecting ray can be used for reproduction. By means of image modulators 14 and use of projected wavelengths in the primary colors red, green and blue, a real image can be

produced on the hologram or the holographic screen. Other possibilities and details of the production are disclosed in the aforementioned document.

[0032] Primarily red, green and blue crystal lasers, glass fiber lasers and diode lasers are used as the source of illumination for the full color imaging at the image modulators 14. The power range of the lasers used is in an order of magnitude of a few milliwatts.

[0033] Suitable full color image modulators are, for example, ferroelectric liquid modulators or micro mirror devices or micro mirror modulators. In this respect different imaging standards, such as VGR, XGR, SXGR, PAL, etc., can be used.

[0034] The ray unit 11 and the holographic screen 13 are synchronized in such a manner that the virtual image 16 appears at a certain distance in front of the windshield 12. Thus, there is no need for the alternating accommodation of the eyes for near and far vision that is otherwise necessary with monitors. In the embodiment, depicted here, the ray unit 11 is disposed in front of the windshield 12 at its lower edge so that the virtual image 16 for the viewer or the car driver 17 lies in the lane 16 or in the visible front parts of the motor vehicle body, such as the hood of the engine. Therefore, the view ahead in the direction of travel is not impaired; and the angular distance between the viewing axis ahead in the direction of travel and the projected image is extremely small. In normal motor vehicles of the conventional type, [said] this view can be set, for

example, to 10 degrees. Even an angular distance of up to 30 degrees means a significant improvement compared to the view in the conventional motor vehicle mirrors or monitors.

[0035] Figure 2 depicts another embodiment of the invention, wherein several images, which are shot by separate camera systems, appear as virtual images 16, 16', 16" in the windshield or front window 12 of the motor vehicle. In this case three projectors with related holographic screens are disposed in the dashboard or behind the dashboard cover. At the windshield 12 there are the ray uniters 11, 11', 11", which lie side by side and are intended to produce the virtual images 16, 16', 16", which are, as seen from the viewer 17, behind the respective ray uniter. The cameras, projectors, holographic screens and ray uniters are arranged in such a manner that the driver 17 of the motor vehicle sees, when looking straight ahead to the front, the ray uniter 11' with the rear image 16', whereas he can see the left rear image 16 or the right rear image 16' through the respective left and right ray uniters 11, 11". Thus, for example, images, as they appear in conventionally arranged rearview and side view mirrors, can be offered in the windshield 12 as virtual images, which are at a viewing location at some distance behind the windshield 12.

[0036] Suitable cameras for shooting outside images are, for example, CCD and CMOS cameras, which cover a wide range of brightness. For example, the glare effect while driving at night can be avoided with highly dynamic CMOS

cameras. It is also possible to install additionally residual light amplifying cameras and un-cooled infrared cameras to improve vision at night. In addition to the significant enlargement of the viewing angle around the car, which is the result of arranging several cameras behind and on the side of the body, a panoramic view around the motor vehicle can be rendered possible with a suitable arrangement of a plurality of cameras.

[0037] Suitable light sources for the projection of images on the holographic screen are, besides lasers, also other monochromatic light sources, such as light emitting diodes. Color imaging is made possible through projection with the primary colors red, green and blue. The virtual images 16, 16', 16" that are produced are projected with sufficient brightness into the windshield 12, where they beam over the image of the environment lying behind it. However, with suitable adjustment of the brightness both images, that is the virtual image 16, 16', 16" and the transparent real image, can also be viewed simultaneously. Since the holographic ray uniter [12] 11 is transparent, the broad band ambient light is allowed to pass virtually unimpeded; and the view through the windshield 12 is completely unimpeded, when the additional image or the virtual image 16, 16', 16" is turned off.

[0038] Since the driver's spatial perception of the distance and the situation of other vehicles or the course of the street is based essentially on a comparison of size and the perspective perception, and less on the stereoscopic vision, a

monoscopic imaging is usually adequate. Therefore, to simplify the construction, one can omit the technically difficult stereoscopic imaging in the holographic projection without any significant loss of information.

[0039] In the described arrangement the driver can see the virtual image or the auxiliary image 16, 16', 16" in the bottom area of the windshield 12. In this outer field, which otherwise remains unused for the driver, the virtual rear or side image is imaged and appears, therefore, for the viewer in the street or the engine hood of the motor vehicle.

[0040] However, it is also possible to have the image appear on a separate transparent plate, mounted in front of the windshield 12. In this case the virtual image appears through the surface of the dashboard.

[0041] In another special embodiment, the fading of the rear and / or side images into the windshield or the vehicle pane 12 is not constantly present, but rather coupled to specific driving states or controls of the motor vehicle. For example, there can be a device, which offers the driver 17 images corresponding to reversing or actuating the blink lights.

[0042] The hologram of the ray unit 12 is designed in such a manner and focused with respect to the holographic screen 13 so that the light cone, issuing from the ray unit 12 in the direction of the driver, is defined by the possible dwelling space of the driver's eyes. The quantity of projected light can be controlled as a function of the light ratio, for example during the day or night.

Owing to the limitation of the light cone and the adjusted quantity of light there is no disturbing brightening of the vehicle interior during the night.

[0043] The inventive imaging with intercalation of a screen hologram and combining of imaging functions for virtual images with the ray unit 11 enable optimal use of the quantity of light for the relatively wide range of motion of the motor vehicle driver 17. Narrow band sources of light, like lasers or light emitting diodes, enable full color imaging in a simple and economical construction.

[0044] In summary the invention makes it possible to fade virtual images directly into the driver's field of vision without disturbing the view ahead.

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Imaging System and Method for Motor Vehicles

The present invention relates to an imaging system for motor vehicles and a method for displaying images in motor vehicles.

It is well-known that the view in the direction of the rear to observe the following traffic from a motor vehicle is rendered possible by means of interior and outside mirrors. This applies both to cars, as well as to trucks and busses. The use and simplicity of such rearview and side view mirrors is undisputed. However, they have several limitations and drawbacks, for example, with respect to safety and economic driving.

One drawback of the interior or rearview mirror is the limitation of the view in the direction of the rear due to the rear window or passengers, located in the motor vehicle. Furthermore, the view by means of the left outside mirror is not complete, but rather has a so-called "dead angle", which is frequently the cause of traffic accidents when changing lanes.

Another grave drawback of the rearview and side view mirrors is that for viewing purposes it is necessary to rotate the view to the side by an angle of approximately 30 degrees to 45 degrees. When the driver looks into the mirror, his attention to the view ahead is extremely limited. The reason lies in the fact that the distinct vision decreases very rapidly with the angular distance from the visual axis; and at a viewing angle exceeding 30 degrees only a weak recognition of outlines and shapes without clear distance perception is possible. This is not at all adequate to react quickly to unexpected traffic obstructions or situations on the street.

In addition, when driving in the dark, the reflection from

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headlights of other motor vehicles is intense in the outside mirrors and the interior rearview mirror. Owing to the blinding effect, this feature is very disturbing and fatigues the driver on long trips. Frequently it is also the cause of accidents.

Since the outside mirrors project beyond the side limits of the motor vehicle body, they can constitute an obstruction or danger for other traffic participants and also be damaged, for example, when driving through very narrow streets or very close to other traffic participants. In addition, the outside mirrors can become rapidly dirty due to their unprotected attachment to the car, thus impairing the view.

Another major drawback of the outside mirrors is their effect on the C value, the result of which is an economic drawback. When driving fast on country roads and freeways, the air resistance of the side mirrors increases the fuel consumption of cars by approximately 5% to 10%. Another disturbing factor is the wind noise, generated during the trip by turbulence at the side mirrors.

A known approach to solving the aforementioned problems lies in the use of cameras, which can be embedded, for example, in the vehicle body. The viewing angle around the vehicle can be significantly increased, for example, with several cameras behind and on the side of the body. Then the image shot with the cameras is displayed on a monitor in the interior of the motor vehicle.

However, the above solution has the drawback that the displayed image is very close to the viewer. In contrast to looking into the conventional rearview or side mirror, looking at the monitor requires that the eyes continuously readapt, a feature that fatigues the driver of the motor vehicle. When the driver's line of vision is directed alternately forward through the windshield or backward through the rearview mirror,

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the eyes must accommodate and converge. In addition, the image on the monitor does not appear vertical in relation to the visual axis, since for space reasons it can hardly be attached in such a manner in the motor vehicle.

Another significant drawback of such systems is the intrinsic brightness of the monitor over a wide solid angle. Thus, the interior of the motor vehicle is significantly brightened in the dark; and the driver's view in the direction of the outside is rendered significantly difficult.

Therefore, the object of the present invention is to provide an imaging system for motor vehicles, which enables a display with high image quality and offers a higher degree of ergonomics and safety in traffic. Furthermore, a method for displaying images in motor vehicles shall be disclosed. Such a method enables the motor vehicle driver to view images with high quality during the trip without diverting his attention or tiring him due to continuous readaptation of the eyes.

This problem is solved by the imaging system, according to patent claim 1, and the method for displaying images in motor vehicles, according to patent claim 13. Other advantageous features, aspects and details of the invention follow from the dependent claims, the description and the drawings.

The inventive imaging system for motor vehicles comprises a holographic screen, which scatters incident narrow band light of one or more wavelengths at a predetermined solid angle, a projector to project images on the holographic screen, and a holographic, transparent ray unit, which allows broad band ambient light to pass in essence unimpeded and which guides the narrow band light, coming from the holographic screen, to the viewer to produce a virtual image at the viewing location.

The invention combines the advantages of conventional

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rearview mirrors, such as high image quality and no necessity of readaptation at rapidly changing distances, with the advantages of camera systems. On the one hand, a high degree of ergonomics and image quality are achieved; and, on the other hand, safety and economic efficiency while driving is increased.

A camera system can be coupled to the imaging system of the invention. Said camera is focused on the rear and / or the side and thus delivers images from the outside of the motor vehicle to enable a view to the rear and / or to the side. From the viewer's viewpoint the ray unit is mounted advantageously in front of and / or directly on the windshield of the motor vehicle. Preferably the ray unit is designed as a holographic mirror or as a ray deflector with lens function. The projector can comprise lasers with the primary colors red, green and blue.

Preferably the projector has an image modulator, for example in the form of ferroelectric liquid modulators or micro mirror devices.

The ray unit can be mounted on a transparent plate, which is made, for example, of glass or plastic. In particular, the holographic ray unit is arranged in such a manner together with the holographic screen that the virtual image appears for the viewer enlarged behind the windshield, preferably at a distance of at least 1.5 meters, especially preferred at a distance of at least 3 meters.

Furthermore, there can be a device for coupling the imaging to vehicle control functions or preset driving situations. The ray unit and / or the holographic screen is / are designed and / or arranged preferably in such a manner that the light cone coming from the ray unit is limited to the possible dwelling space of the viewer's eyes. Preferably the holographic screen and the ray unit are designed and / or arranged in such a manner that they exhibit an imaging function.

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The inventive method for displaying images in motor vehicles comprises the steps:

Project images on a holographic screen and guide the light rays, coming from the holographic screen, into a viewer's eyes, whereby virtual images are produced in a surface cutout of the front window and / or windshield by means of a hologram, whose purpose is ray deflection and which is connected in series to the holographic screen. Thus, the ergonomics while driving motor vehicles is increased; and images of the outside can be offered with high quality to the motor vehicle driver, whereby the aforementioned drawbacks of rearview or side mirrors and monitors are overcome.

With this method the images can be taken with a camera system in order to enable in the windshield the view in the direction of the rear and / or to the side. Preferably images of the view toward the rear and / or from the perspective of the vehicle side mirrors are faded into the peripheral area of the windshield. Preferably the angular distance between the visual axis of the vehicle driver in the direction of travel and the virtual image is less than 30 degrees, especially preferred approximately 10 degrees. Furthermore, the rear and side images from the motor vehicle can be displayed as a function of the driving states or the vehicle control functions.

The invention is described as an illustrative example with reference to the figures, where

Figure 1 is a longitudinal view of the motor vehicle with the inventive imaging system and the beam trajectory; and

Figure 2 is a sectional view from the top with different ray paths in a car, according to a specific embodiment of the invention.

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Figure 1 is a side view or a sectional view of the central plane of the driver of a motor vehicle to depict as a schematic the imaging system and the beam trajectory, according to a preferred embodiment of the invention. In the motor vehicle there is a holographic screen 13, which is produced by means of a holographic shot of a real screen. By means of an image modulator 14 and a lens 15 light is projected on the holographic screen 13 to display images. In this manner images, produced by a light source and the image modulator 14, are imaged as real through the lens 15 on the holographic screen 13. A holographic, transparent ray uniter 11 or combiner is arranged in such a manner that it deflects or almost completely reflects the light rays, issuing from the holographic screen 13 as a consequence of the image projection, in the direction of the viewer 17. The holographic, transparent ray uniter 11 comprises a hologram with the imaging properties of a concave mirror or a lens so that, when viewing the ray uniter 11, a virtual image 16 is produced at the viewing location of the driver 17.

The ray uniter 11 is arranged, as seen from the viewer 17, in front of the windshield 12 of the motor vehicle. Owing to its design as a transparent hologram, it allows the broad band light, coming from the outside through the windshield 12, to pass through virtually unimpeded so that the driver can look out through the ray uniter 11. However, the hologram of the ray uniter 11 is designed in such a manner that narrow band or monochromatic light, for example laser light in the primary colors red, green and blue, which comes from the holographic screen 13, is reflected almost completely in the direction of the driver.

In the embodiment, depicted here, the projector, comprising modulator 14 and lens 15, and the holographic screen 13 are arranged inside the dashboard of the motor vehicle. Through an opening, which is adapted to the opening angle 18 of the ray trajectory between the holographic screen 13 and the ray uniter

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11, the light rays pass through the ray uniter 11 to the viewer 17.

In the embodiment, depicted here, the ray uniter 11 is designed as a holographic mirror. It can be mounted either directly on the windshield 12 or on a separate transparent plate, which is disposed in front of the windshield 12. As an alternative, it is also possible that the ray uniter 11 is designed in transmission, whereby it exhibits a lens function, which causes a suitable deflection of the light rays.

Photopolymer, photoresist, silver halide and dichromated gelatin holograms can be used, for example, as holographic materials or holograms for the holographic screen 13 and the ray uniter 12. The holographic screen 13 and the ray uniter 12 can be designed to work in reflection or also in transmission.

The holographic screen 13 and its production are detailed in the DE 197 00 162 A1 document, to which explicit reference is made. In production, a real, for example white, screen is imprinted into a hologram with the projected laser wavelengths that are used later. During the shooting process it is provided that the screen is illuminated in such a manner with the lens ray that its backscatter characteristic is the same as desired later in application. An expanded pencil of rays, which issues from a corresponding location, like the subsequent projecting ray, serves as the reference ray during holographic shooting of the screen. For example, a scanning projecting ray can be used for reproduction. By means of image modulators 14 and use of projected wavelengths in the primary colors red, green and blue, a real image can be produced on the hologram or the holographic screen. Other possibilities and details of the production are disclosed in the aforementioned document.

Primarily red, green and blue crystal lasers, glass fiber lasers and diode lasers are used as the source of illumination

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for the full color imaging at the image modulators 14. The power range of the lasers used is in an order of magnitude of a few milliwatts.

Suitable full color image modulators are, for example, ferroelectric liquid modulators or micro mirror devices or micro mirror modulators. In this respect different imaging standards, such as VGR, XGR, SXGR, PAL, etc., can be used.

The ray uniter 11 and the holographic screen 13 are synchronized in such a manner that the virtual image 16 appears at a certain distance in front of the windshield 12. Thus, there is no need for the alternating accommodation of the eyes for near and far vision that is otherwise necessary with monitors. In the embodiment, depicted here, the ray uniter 11 is disposed in front of the windshield 12 at its lower edge so that the virtual image 16 for the viewer or the car driver 17 lies in the lane 16 or in the visible front parts of the motor vehicle body, such as the hood of the engine. Therefore, the view ahead in the direction of travel is not impaired; and the angular distance between the viewing axis ahead in the direction of travel and the projected image is extremely small. In normal motor vehicles of the conventional type, said view can be set, for example, to 10 degrees. Even an angular distance of up to 30 degrees means a significant improvement compared to the view in the conventional motor vehicle mirrors or monitors.

Figure 2 depicts another embodiment of the invention, wherein several images, which are shot by separate camera systems, appear as virtual images 16, 16', 16" in the windshield or front window 12 of the motor vehicle. In this case three projectors with related holographic screens are disposed in the dashboard or behind the dashboard cover. At the windshield 12 there are the ray uniters 11, 11', 11", which lie side by side and are intended to produce the virtual images 16, 16', 16", which are, as seen from the viewer 17, behind the respective ray

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uniter. The cameras, projectors, holographic screens and ray uniters are arranged in such a manner that the driver 17 of the motor vehicle sees, when looking straight ahead to the front, the ray uniter 11' with the rear image 16', whereas he can see the left rear image 16 or the right rear image 16' through the respective left and right ray uniters 11, 11". Thus, for example, images, as they appear in conventionally arranged rearview and side view mirrors, can be offered in the windshield 12 as virtual images, which are at a viewing location at some distance behind the windshield 12.

Suitable cameras for shooting outside images are, for example, CCD and CMOS cameras, which cover a wide range of brightness. For example, the glare effect while driving at night can be avoided with highly dynamic CMOS cameras. It is also possible to install additionally residual light amplifying cameras and un-cooled infrared cameras to improve vision at night. In addition to the significant enlargement of the viewing angle around the car, which is the result of arranging several cameras behind and on the side of the body, a panoramic view around the motor vehicle can be rendered possible with a suitable arrangement of a plurality of cameras.

Suitable light sources for the projection of images on the holographic screen are, besides lasers, also other monochromatic light sources, such as light emitting diodes. Color imaging is made possible through projection with the primary colors red, green and blue. The virtual images 16, 16', 16" that are produced are projected with sufficient brightness into the windshield 12, where they beam over the image of the environment lying behind it. However, with suitable adjustment of the brightness both images, that is the virtual image 16, 16', 16" and the transparent real image, can also be viewed simultaneously. Since the holographic ray uniter 12 is transparent, the broad band ambient light is allowed to pass virtually unimpeded; and the view through the windshield 12 is

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completely unimpeded, when the additional image or the virtual image 16, 16', 16" is turned off.

Since the driver's spatial perception of the distance and the situation of other vehicles or the course of the street is based essentially on a comparison of size and the perspective perception, and less on the stereoscopic vision, a monoscopic imaging is usually adequate. Therefore, to simplify the construction, one can omit the technically difficult stereoscopic imaging in the holographic projection without any significant loss of information.

In the described arrangement the driver can see the virtual image or the auxiliary image 16, 16', 16" in the bottom area of the windshield 12. In this outer field, which otherwise remains unused for the driver, the virtual rear or side image is imaged and appears, therefore, for the viewer in the street or the engine hood of the motor vehicle.

However, it is also possible to have the image appear on a separate transparent plate, mounted in front of the windshield 12. In this case the virtual image appears through the surface of the dashboard.

In another special embodiment, the fading of the rear and / or side images into the windshield or the vehicle pane 12 is not constantly present, but rather coupled to specific driving states or controls of the motor vehicle. For example, there can be a device, which offers the driver 17 images corresponding to reversing or actuating the blink lights.

The hologram of the ray unit 12 is designed in such a manner and focused with respect to the holographic screen 13 that the light cone, issuing from the ray unit 12 in the direction of the driver, is defined by the possible dwelling space of the driver's eyes. The quantity of projected light can

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be controlled as a function of the light ratio, for example during the day or night. Owing to the limitation of the light cone and the adjusted quantity of light there is no disturbing brightening of the vehicle interior during the night.

The inventive imaging with intercalation of a screen hologram and combining of imaging functions for virtual images with the ray uniter 11 enable optimal use of the quantity of light for the relatively wide range of motion of the motor vehicle driver 17. Narrow band sources of light, like lasers or light emitting diodes, enable full color imaging in a simple and economical construction.

In summary the invention makes it possible to fade virtual images directly into the driver's field of vision without disturbing the view ahead.

Patent Claims

1. Imaging system for motor vehicles, comprising a projector (14, 15), and a holographic ray uniter (11, 11', 11"), which guides narrow band light to a viewer (17) to produce a virtual image (16, 16', 16") at the viewing location, characterized by a holographic screen (13), which is produced by means of holographic shooting of a real screen and scatters incident narrow band light of one or more wavelengths at a predetermined solid angle, whereby the projector (14, 15) projects the light onto the holographic screen (13) to produce there real images, and the holographic ray uniter (11, 11', 11") is transparent to broad band ambient light; and the narrow band light, scattered by the holographic screen (13), is guided to the viewer (17).
2. Imaging system, as claimed in claim 1, characterized by a camera system, which is coupled to the projector, to shoot images outside the motor vehicle to enable the view to the rear and / or to the side.
3. Imaging system, as claimed in claim 1 or 2, characterized in that the holographic ray uniter (11, 11', 11") is arranged, from the viewer's view, in front of and / or on the windshield (12) of the motor vehicle.
4. Imaging system, as claimed in one or more of the preceding claims, characterized in that the ray uniter (11, 11', 11") is designed as a holographic mirror.
5. Imaging system, as claimed in one or more of the preceding claims, characterized in that the ray uniter (11, 11', 11") is designed as a ray deflector with lens function.

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6. Imaging system, as claimed in one or more of the preceding claims, characterized in that the projector (14, 15) comprises lasers with the primary colors red, green and blue.
7. Imaging system, as claimed in one or more of the preceding claims, characterized in that the projector (14, 15) comprises an image modulator (14), in particular ferroelectric liquid modulators and / or micro mirror devices.
8. Imaging system, as claimed in one or more of the preceding claims, characterized in that the ray uniter (11, 11', 11") is disposed on a transparent plate.
9. Imaging system, as claimed in one or more of the preceding claims, characterized in that the holographic ray uniter (11, 11', 11") and the holographic screen (13) are arranged in such a manner that the virtual image appears for the viewer (17) enlarged behind the windshield (12) of the motor vehicle, preferably at a distance of at least 1.5 meters to the viewer, especially preferred at a distance of at least 3 meters.
10. Imaging system, as claimed in one or more of the preceding claims, characterized by a device for coupling the imaging to vehicle control functions and / or the motor vehicle control functions.
11. Imaging system, as claimed in one or more of the preceding claims, characterized in that the ray uniter (11, 11', 11") and / or the holographic screen (13) is / are designed and arranged in such a manner that the light cone coming from the ray uniter (11, 11', 11") is limited to the possible dwelling space of the viewer's (17) eyes.

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12. Imaging system, as claimed in one or more of the preceding claims, characterized in that the ray uniter (11, 11', 11") and / or the holographic screen (13) is / are designed and arranged in such a manner that they exhibit an imaging function.

13. Method for displaying images in motor vehicles with the steps:

Project images on a holographic screen (13) and guide the light rays, coming from the holographic screen (13), into a viewer's (17) eyes, whereby virtual images (16, 16', 16") are produced in a surface cutout of the windshield (12) of the motor vehicle by means of a hologram, whose purpose is ray deflection (11, 11', 11") and which is connected in series to the holographic screen (13).

14. Method for displaying images in motor vehicles with the steps:

Project narrow band light of one or more wavelengths on a holographic screen (13), which is produced by holographic shooting of a real screen, to produce a real image on the holographic screen (13), and

guide the light rays, scattered by the holographic screen (13) at a predetermined solid angle, into a viewer's (17) eye,

whereby the light rays are deflected through a hologram and produce a virtual image at the viewer (17), while simultaneously broad band light of the environment lying behind the hologram passes through the hologram.

15. Method, as claimed in claim 13 or 14, wherein images (16, 16', 16") of the view to the rear and / or from the perspective of the motor vehicle side mirrors are faded into the peripheral area of the windshield (12).

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16. Method, as claimed in one or more of the claims 13 to 15, wherein the angular distance between the visual axis in the direction of travel and the virtual image (16, 16', 16") is less than 30 degrees, preferably approximately 10 degrees.
17. Method, as claimed in one or more of the claims 13 to 16, wherein the rear and / or side images from the motor vehicle are displayed as a function of the driving state or the motor vehicle control functions.

Abstract

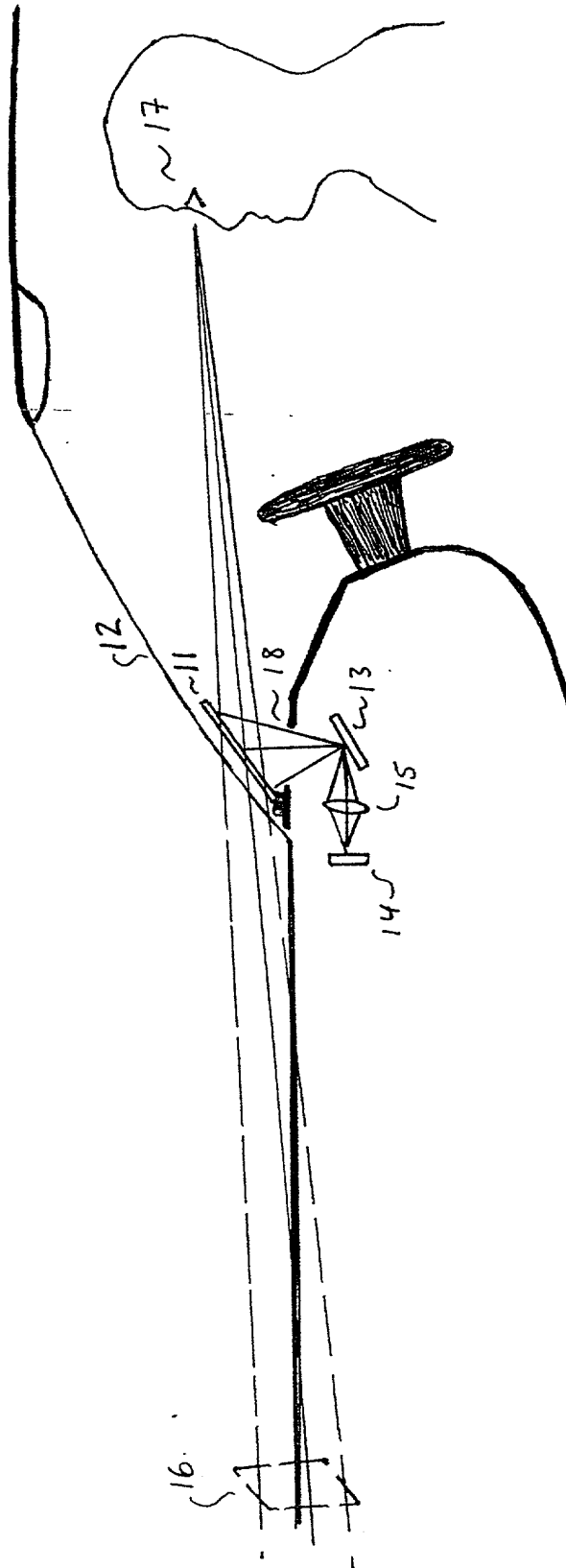
An imaging system for motor vehicles has a holographic screen (13), which scatters incident narrow band light at a predetermined solid angle, and a modulator (14) and a lens (15) to project images on the holographic screen (13). A holographic, transparent ray uniter (11), which allows broad band ambient light to pass through essentially unimpeded, guides the narrow band light, coming from the holographic screen (13), to the viewer (17), whereby a virtual image (16) is produced at the viewing location by means of an imaging function. Images from the outside of the motor vehicle are shot by means of a camera system and are faded as virtual images into the windshield (12) of the motor vehicle in order to enable there additionally a view to the rear or to the side.

(Figure 1)

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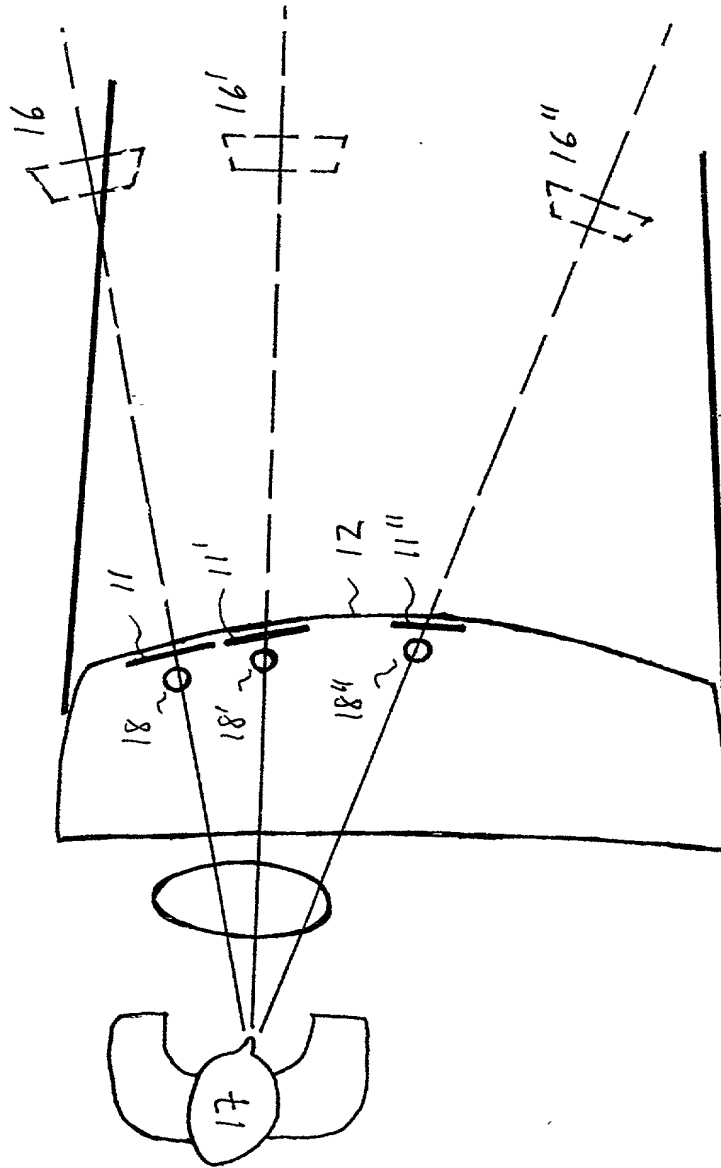
Fig. 1



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Fig. 2



**COMBINED DECLARATION FOR PATENT APPLICATION AND
POWER OF ATTORNEY**

(includes Reference to PCT International Applications)

ATTORNEY'S DOCKET
NUMBER

420/50771

As a below named inventor, I hereby declare that:

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My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

IMAGE REPRESENTATION SYSTEM AND METHOD FOR VEHICLES

the specification of which (check only one item below):

☐ is attached hereto.☐ was filed as United States application
Serial No.

on

And was amended

on _____ (if applicable).

☒ was filed as PCT international application
Number PCT/DE00/02115 on June 28, 2000
and was amended under PCT Article 19
on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations. §1.56(a).

I hereby claim foreign priority benefits under Title 35, United State Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. 119:

COUNTRY (if PCT indicate PCT)	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 USC 119
Germany	199 30 710.5	July 2, 1999	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No

Combined Declaration For Patent Application and Power of Attorney (Continued) (includes Reference to PCT international Applications)	ATTORNEY'S DOCKET NUMBER 420/50771
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I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application(s) and the national of PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120

U.S. APPLICATIONS			STATUS (Check one)		
U.S. APPLICATION NUMBER	U.S. FILING DATE		PATENTED	PENDING	ABANDONED
PCT APPLICATIONS DESIGNATING THE U.S.					
PCT APPLICATION NO	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED (IF ANY)			

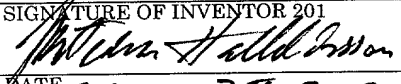
POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (List name and registration number)

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201	FULL NAME OF INVENTOR	FAMILY NAME HALLDORSSON	FIRST GIVEN NAME Thorsteinn	SECOND GIVEN NAME
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	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY
203	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true: and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201 	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
DATE February 7th 2002	Date	DATE